MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2022 / 2023 (2230)

PPH0046 - MECHANICS

(Foundation in Engineering)

3 OCTOBER 2023
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **FOUR** printed pages, excluding the cover page and appendices, with **FIVE** questions.
2. Answer all questions. The distribution of the marks for each question is given.
3. Write all your answers in the answer booklet provided.
4. All necessary workings must be shown.

QUESTION 1 (10 marks)

a) Given $\mathbf{A} = 5\mathbf{j} - 7\mathbf{k}$ and $\mathbf{B} = 4\mathbf{i} - \mathbf{k}$. Find the vector that is perpendicular to both **A** and **B**.

(2 marks)

b) A jogger runs along a straight and level road for a distance of 8.0 km and then runs back to her starting point. The time for this round-trip is 2.0 h. Calculate the jogger's average velocity.

(2 marks)

c) A 5.0-kg mass is pulled along a rough horizontal table by a horizontal force of magnitude 20.0 N against a constant friction force of magnitude 5.0 N. Find the acceleration of the mass.

(2 marks)

d) **Figure Q1** shows a uniform rod of length 3.0 m and weight 20.0 N resting horizontally on supports 2.0 m apart. Calculate the magnitude of the reaction of the support at the end of the rod.

(2 marks)

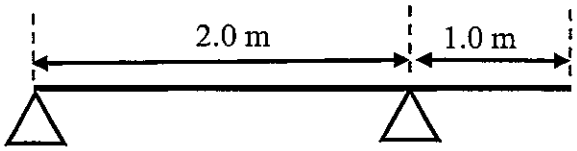

Figure Q1

e) A lorry of mass 3000.0 kg is initially travelling at 30.0 m/s. The brakes are applied, causing the lorry to decelerate at 1.5 m/s^2 for 6.0 s. Calculate the loss of kinetic energy of the lorry.

(2 marks)

Continued...

QUESTION 2 (10 marks)

a) A wheel released from rest is rotating with constant angular acceleration of 2.6 rad/s^2. At 6.0 s after the release:

i. What is its angular speed?

(1 mark)

ii. Through what angle has the wheel turned?

(1 mark)

iii. How many revolutions has it completed?

(1 mark)

iv. What is the linear speed of a point 0.3 m from the axis of rotation?

(1 mark)

b) A 2000-kg block is lifted at a constant speed of 0.08 m/s by a steel cable that passes over a massless pulley to a motor-driven winch (**Figure Q2**). The radius of the winch drum is 0.3 m.

i. What is the tension in the cable?

(1 mark)

ii. What torque does the cable exert on the winch drum?

(1 mark)

iii. What is the angular speed of the winch drum?

(1 mark)

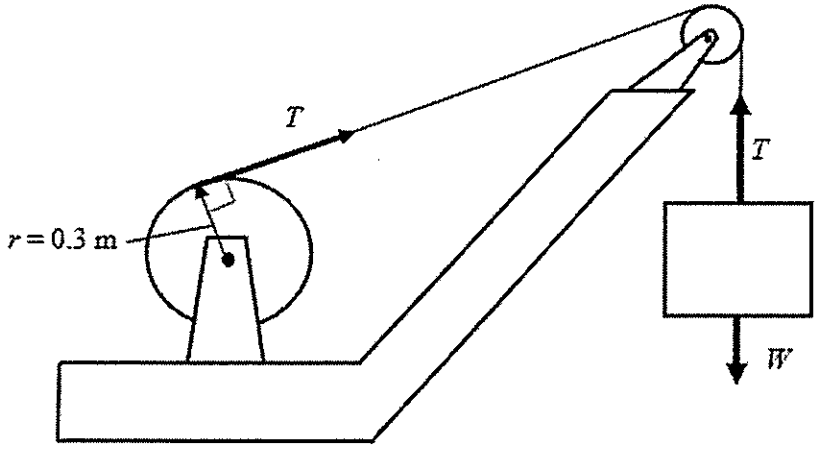

Figure Q2

c) You stand on a frictionless platform that is rotating at an angular speed of 1.5 rev/s. Your arms are outstretched, and you hold a heavy weight in each hand. The moment of inertia of you, the extended weights, and the platform is 6.0 kg.m^2. When you pull the weights in toward your body, the moment of inertia decreases to 1.8 kg.m^2

i. What is the resulting angular speed of the system?

(1 mark)

ii. What is the change in kinetic energy of the system?

(2 marks)

Continued...

QUESTION 3 (10 marks)

a) Five identical masses ($M = 5$ kg), are equally spaced on the arc of a semicircle of radius $r = 10.0$ cm, as shown in **Figure Q3**. A smaller mass $m = 2$ kg is located at the centre of curvature of the arc. Determine the resultant gravitational force on the particle m due to the other five masses.

(5 marks)

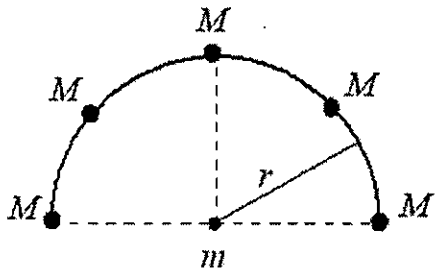

Figure Q3

b) A satellite is circling the moon (radius 1700 km) close to the surface at a speed v. A projectile is launched vertically up from the moon's surface at the same initial speed. How high will the projectile rise?

(5 marks)

QUESTION 4 (10 marks)

A uniform bar PQ of negligible mass is suspended horizontally from two long vertical wires as shown in **FigureQ4**. One wire is made of brass and the other of steel. Each wire is 2.5 m long but they have different cross-sectional areas. The Young moduli for brass and steel are 1.0×10^{11} N/m^2 and 2.0×10^{11} N/m^2 respectively.

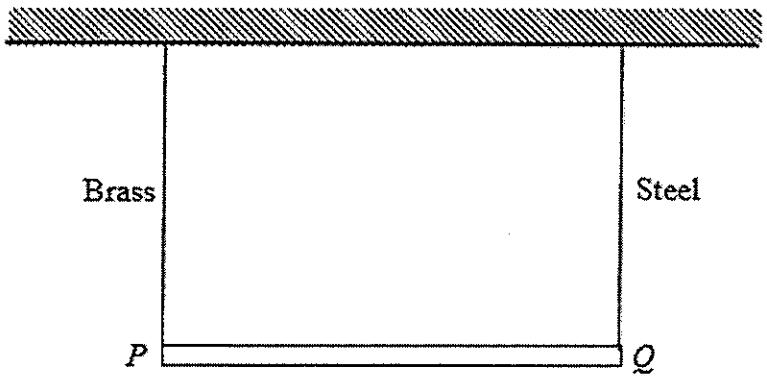

Figure Q4

When a mass of 16.0 kg is suspended from the centre of PQ, the bar remains horizontal.

Continued...

a) What is the tension in each wire?

(4 marks)

b) If the cross-sectional area of the steel wire is 2.8×10^{-7} m^2, calculate its extension.

(2 marks)

c) Calculate the cross-sectional area of the brass wire.

(2 marks)

d) Calculate the energy stored in the steel wire.

(1 mark)

e) If the brass wire is replaced with a steel wire of the same dimensions of the brass wire, calculate its extension. The same mass is suspended from the midpoint of PQ.

(1 mark)

QUESTION 5 (10 marks)

The position of a particle is given by $x = (7.0 \text{ cm}) \cos(6\pi t)$, where t is in seconds.

a) Determine the frequency, period and amplitude of the motion.

(3 marks)

b) Calculate the maximum speed of the motion.

(1 mark)

c) Write the equation representing the velocity of the motion.

(1 mark)

d) What is the first time after $t = 0$ that the particle is at its equilibrium position?

(3 marks)

e) Determine the speed of the particle in part (d)

(2 marks)

End of page

APPENDIX I

Physical Constants

Quantity	Symbol	Value
Electron mass	m_e	9.11×10^{-31} kg
Proton mass,	m_p	1.67×10^{-27} kg
Elementary charge	e	1.602×10^{-19} C
Gravitational constant	G	6.67×10^{-11} N.m^2 /kg^2
Gas constant	R	8.314 J/K.mol
Hydrogen ground state	E_o	-13.6 eV
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Compton wavelength	λ_c	2.426×10^{-12} m
Planck's constant	h	6.626×10^{-34} J.s
Speed of light in vacuum	c	3.0×10^8 m/s
Rydberg constant	R_H	1.097×10^7 m^{-1}
Acceleration due to gravity,	g	9.8 m /s^2
Atomic mass unit (1u)	u	1.66×10^{-27} kg
Avogadro's number	N_A	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing	I_o	1.0×10^{-12} W /m^2
Coulomb constant	k	9.0×10^9 N m^2 /C^2
Permittivity of free space	ϵ_o/κ_o	8.85×10^{-12} C^2/N.m^2
Permeability of free space	μ_o	$4\pi \times 10^{-7}$ H/m

Energy equivalent of atomic mass unit:

One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

Earth:

Gravity	=	9.8 m/s^2
Radius	=	6.4×10^6 m
Mass	=	6.0×10^{24} kg

Moon:

Mass	=	7.4×10^{22} kg
Radius	=	1.7×10^6 m

Sun:

Mass	=	2.0×10^{30} kg
Radius	=	6.96×10^8 m

Mean distance from:

Sun to Earth	=	1.50×10^{11} m
Moon to Earth	=	3.85×10^8 m

APPENDIX II

List of formulas

$y = kx^n$ $\frac{dy}{dx} = knx^{n-1}$	$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ $\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$ $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$ $\sin\alpha + \sin\beta = 2\cos\left(\frac{\alpha-\beta}{2}\right)\sin\left(\frac{\alpha+\beta}{2}\right)$ $\sin(\alpha-\beta) + \sin(\alpha+\beta) = 2\sin\alpha\cos\beta$

$v = v_o + gt$ $\quad y - y_o = v_o t + \frac{1}{2}gt^2$ $\quad v^2 = v_o^2 + 2g(y - y_o)$

$y - y_o = \left(\frac{v_o + v}{2}\right)t$

$a_c = \frac{v^2}{r}$ $\quad F_g = G\frac{m_1 m_2}{r^2}$ $\quad U_g = -G\frac{m_1 m_2}{r}$ $\quad T^2 = K_s r^3$

$\tau = r \times F$ $\quad \sum\tau = \tau_{net} = I\alpha$ $\quad I = \sum mr^2$

$v = r\omega$

$L = r \times p = I\omega$ $\quad K = \frac{1}{2}I\omega^2$ $\quad |\tau| = |r||F|\sin\theta$

$T_s = 2\pi\sqrt{\frac{m}{k}}$ $\quad T_p = 2\pi\sqrt{\frac{l}{g}}$ $\quad T = \frac{2\pi}{\omega} = \frac{1}{f}$ $\quad \bar{y} = \frac{\sum_{i=1}^{N} m_i y_i}{\sum_{i=1}^{N} m_i}$

$x = A\cos\omega t$ $\quad x = A\sin\omega t$

$v = -\omega A\sin\omega t$ $\quad v = \omega A\cos\omega t$ $\quad W_F = |r||F|\cos\theta$

$a = -\omega^2 A\cos\omega t$ $\quad a = -\omega^2 A\sin\omega t$

$v = \frac{\Delta x}{\Delta t}$ $\quad a = \frac{\Delta v}{\Delta t}$

$v = v_o + at$ $\quad x - x_o = v_o t + \frac{1}{2}at^2$ $\quad v^2 = v_o^2 + 2a(x - x_o)$ $\quad x - x_o = \left(\frac{v_o + v}{2}\right)t$

$W = mg$ $\quad \sum F = F_{net} = ma$ $\quad f_s \le \mu_S F_N$ $\quad f_k = \mu_K F_N$

$p = mv$ $\quad \sum F = \frac{\Delta p}{\Delta t}$ $\quad \Sigma W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $\quad m_1u_1 + m_2u_2 = (m_1 + m_2)v$ $\quad P = \frac{W}{t} = \frac{E}{t} = \frac{Fd}{t} = F\bar{v}$

$K = \frac{1}{2}mv^2$ $\quad PE_s = \frac{1}{2}kx^2$ $\quad F_s = -kx$ $\quad PE_G = mgy$

$\bar{x} = \frac{\sum_{i=1}^{N} m_i x_i}{\sum_{i=1}^{N} m_i}$ $\quad W_{Fs} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$